

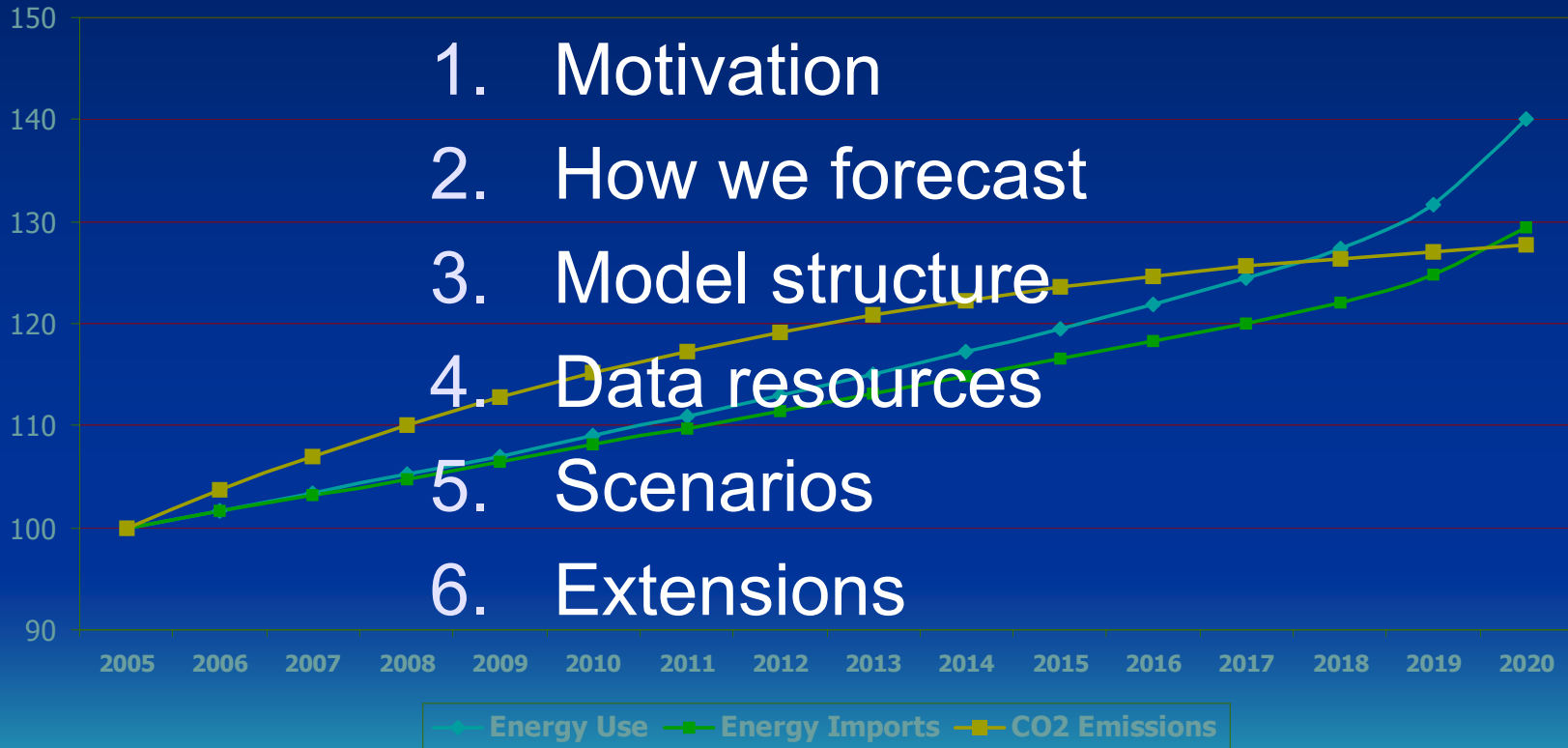
A Dynamic General Equilibrium Model of California Climate Change

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Motivation – Why use an economic model?

- Most human-induced environmental change originates in economic activity.
- Environmental effects of policy will largely result from economic responses.
- Thus, to understand environmental incidence, we need to understand economic behavior.

Why a state model?

1. California is unique
2. National assessment masks extensive interstate spillovers and trade-offs
3. California needs capacity to support its own policies

Why use a general equilibrium model?

1. Complexity - Given the complexity of today's economy, policy makers relying on intuition and rules-of-thumb alone are unlikely to achieve anything approaching optimality.
2. Linkage - Indirect effects of policies often outweigh direct effects.
3. Political sustainability - Economic policy may be made from the top down, but the political consequences of economic activity are ultimately felt from the bottom up. Stakeholders must be identifiable and their interests assessed.

GE models, supported by detailed data, can elucidate these linkages and improve visibility for policy makers.

What is a General Equilibrium Model?

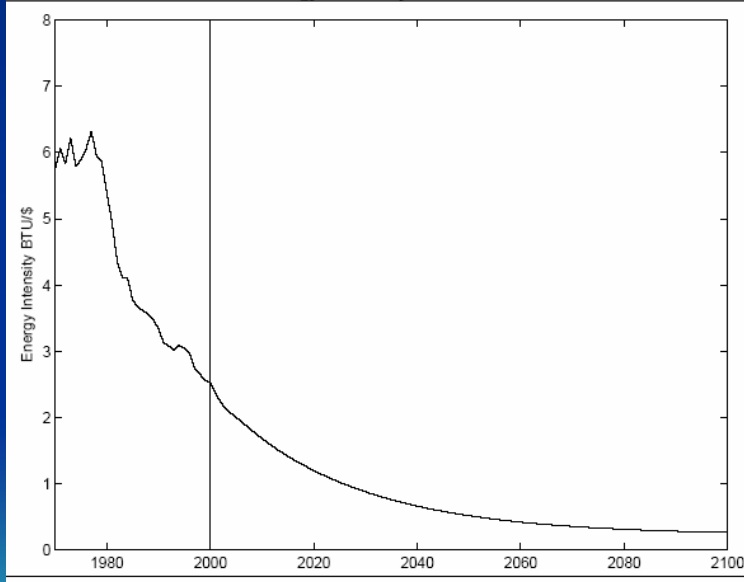
- GE models capture detailed market and non-market interactions in a consistent empirical framework.
- Linkages between behavior, incentives, and policies reveal how patterns of demand, supply, and resource use change in response to external shocks and policy changes.

Two-stage Forecasting

- Long term – to 2100
 - Econometric time series projections of aggregate growth, resource use, and emissions trends
- Medium term – to 2020
 - GE modeling of detailed structural adjustment around calibrated macro trends

Long Term Econometric Forecasts

FIGURE 5. Forecasts Energy Intensity Petroleum Products All Sectors



Source: Aufhammer & Roland-Holst

FIGURE 6. Forecasts Energy Intensity Gas All Sectors

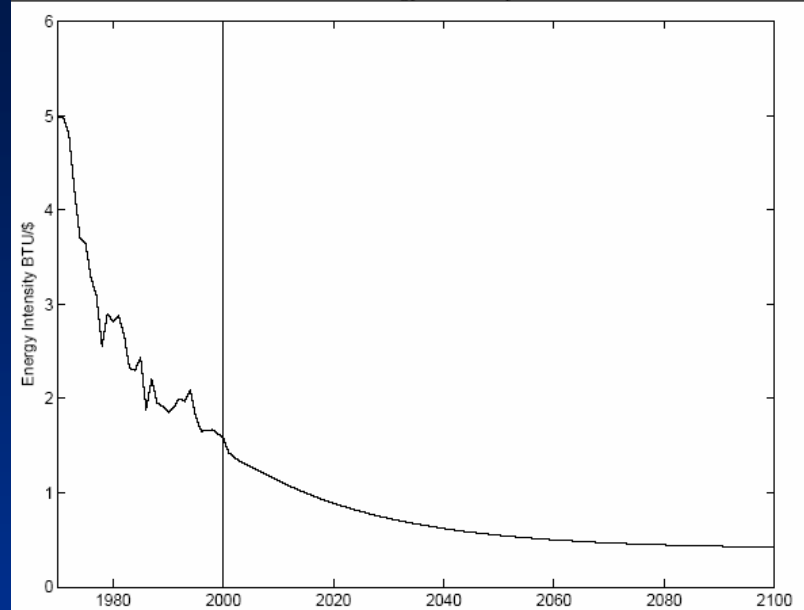
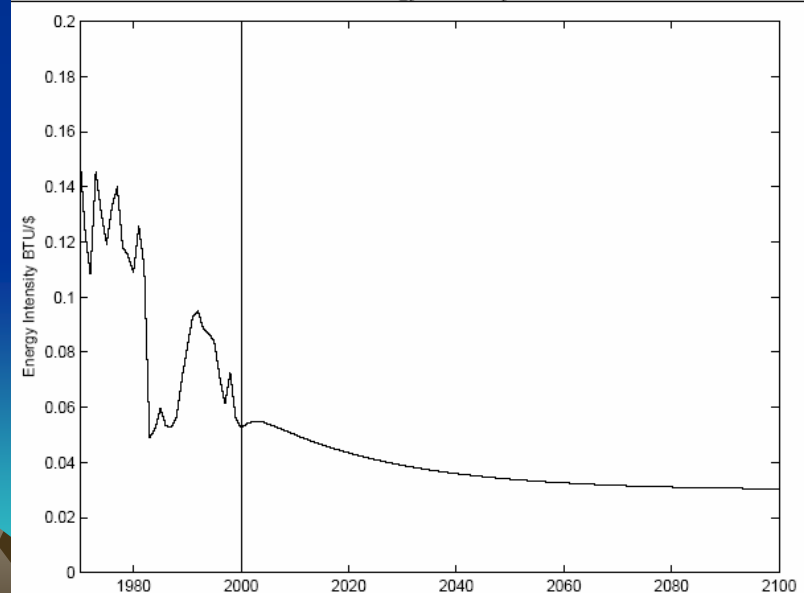
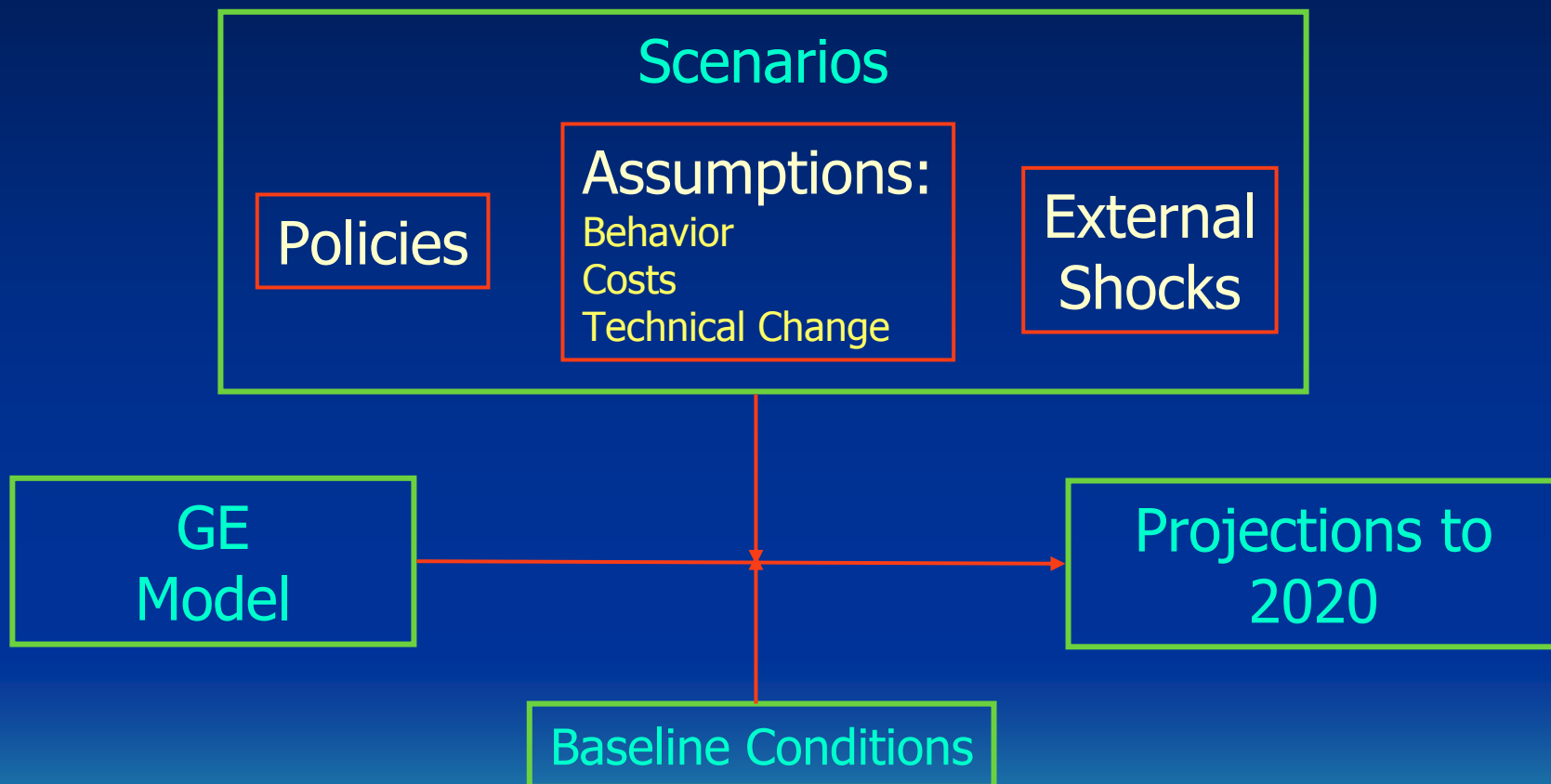


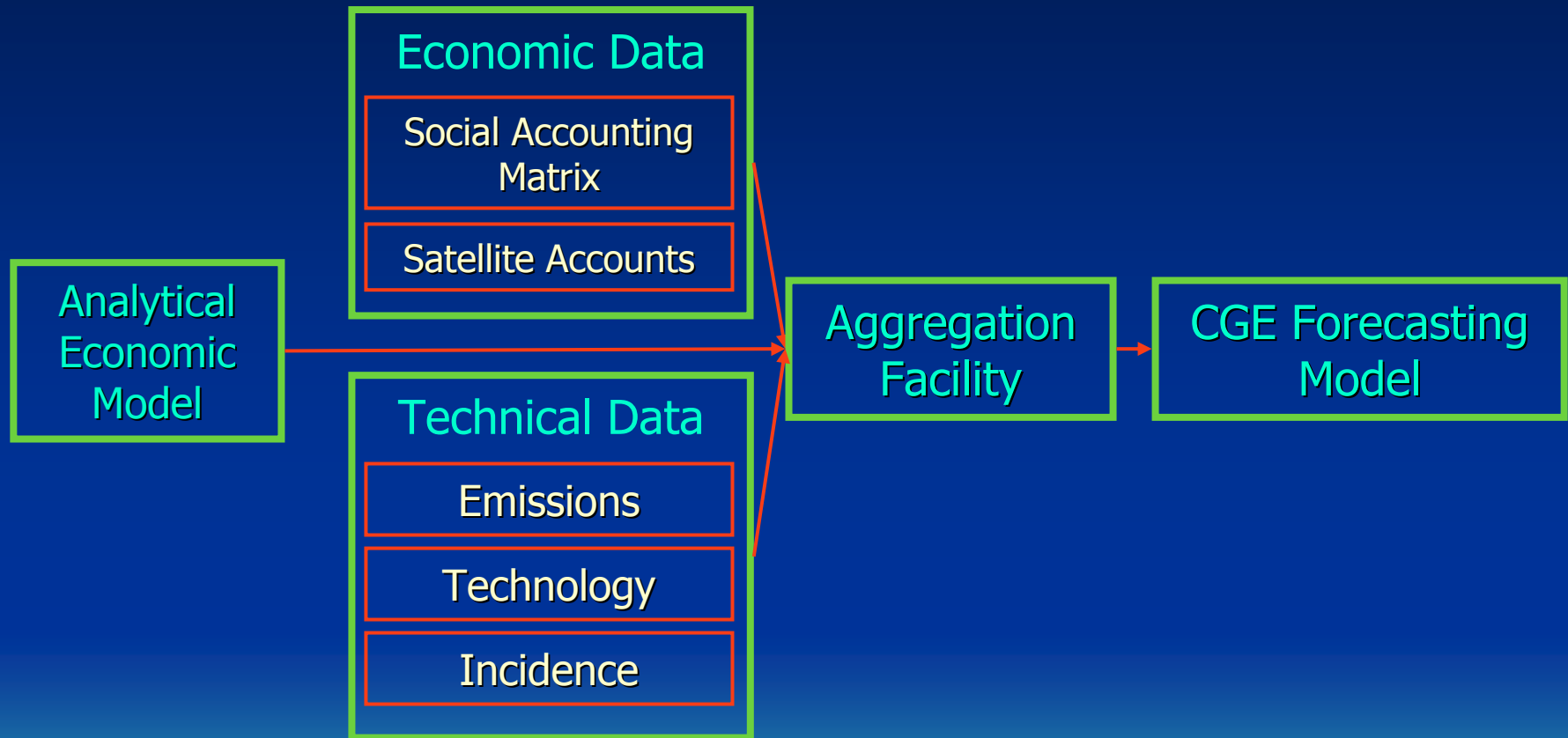
FIGURE 7. Forecasts Energy Intensity Coal All Sectors



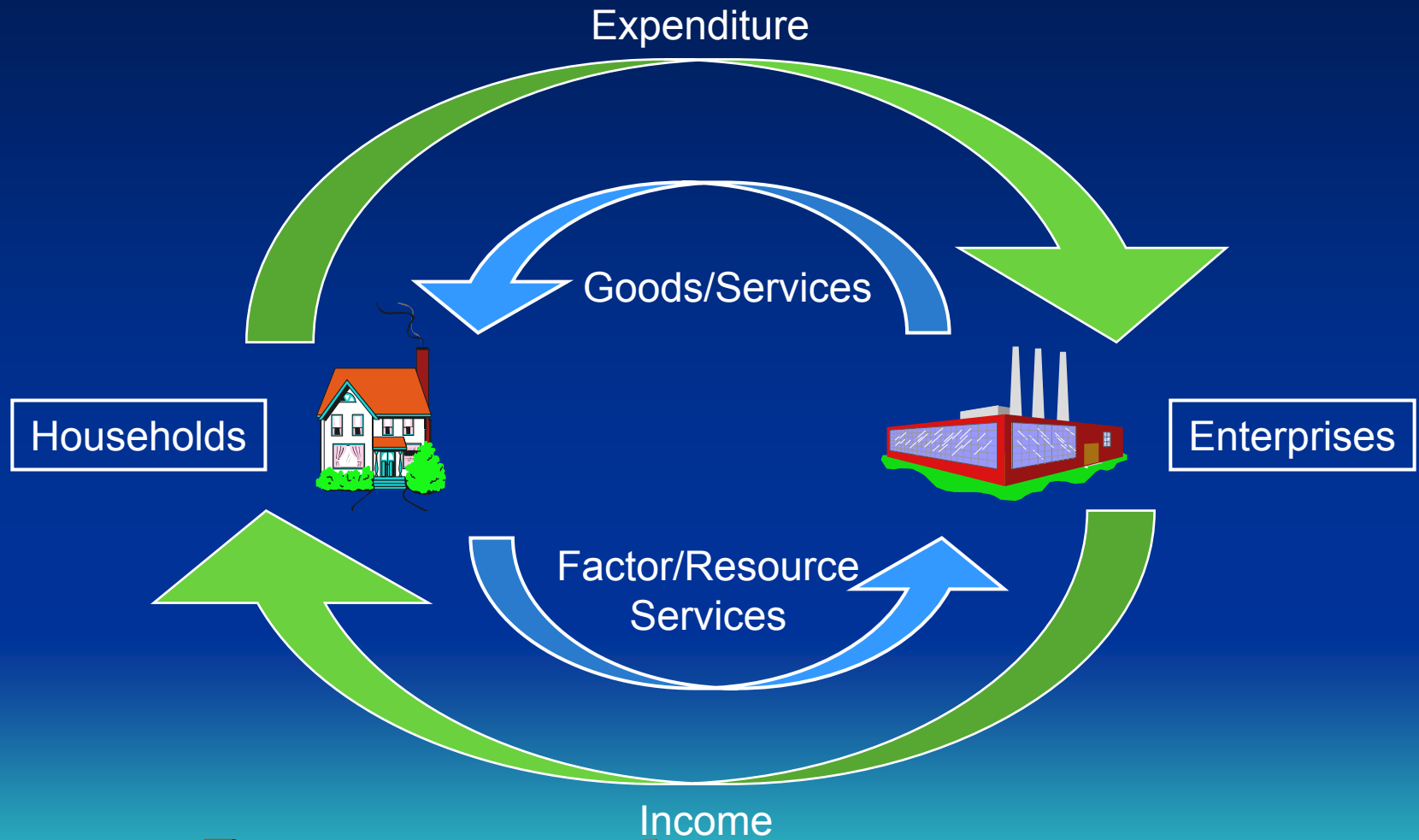
Forward-looking Medium Term Policy Analysis



Berkeley Energy And Resource (BEAR) Model: General Structure of the Model



General Equilibrium: The Circular Flow of Expenditure and Income



General Equilibrium: From Production to Employment to Expenditure

Three main endogenous components of economic activity

1. Production activities use factor services and resources
2. ...leading to factor employment and income (wages, rents, profits)
3. ...sustaining demand for goods and services.

The GE model follows these cycles for very detailed activities and markets.

- Taxes and government policies influence all three
- Trade with other regions/countries further complicates the story
- Environmental incidence
 - Pollution and its effects
 - Resource use/depletion

Modeling Behavior

Advanced economic theory is used to capture:

Supply - The key is to emulate substitution and complementarity relations across factors of production and intermediate inputs.

Demand - Same motivation, to emulate observed substitution and complementarity relations across goods/ services, and in the relation between income and demand.

Modeling Economy-Environment Linkage

Economic activity affects pollution in three ways:

1. Growth – aggregate growth increases resource use
2. Composition – changing sectoral composition of economic activity can change aggregate pollution intensity
3. Technology – any activity can change its pollution intensity with technological change

All three components interact to determine the ultimate effect of the economy on environment.

Data Structure

- Economic Data
 - Social Accounting Matrix
 - Satellite Accounts
 - Trends
- Pollution
- Energy
- Other Resources (water, land)

Economic Data 1

California Social Accounting Matrix (2003)

An economy-wide accounting device that captures detailed income-expenditure linkages between economic institutions. An extension of input-output analysis.

- 104 sectors/commodities
- Three factor types
 - Labor (2+ occupational categories)
 - Capital
 - Land
- Households (10 by tax bracket)
- Fed, State, and Local Government (very detailed fiscal instruments, 45 currently)
- Consolidated capital account
- US and ROW trading partners

Economic Data 2

Satellite Accounts

- Employment
- Econometrically estimated parameters
- Trends for calibration
 - Population and other labor force composition
 - Independent macro trends (US, ROW, etc.)
 - Productivity growth trends
 - Exogenous prices (energy and other commodities)

Pollution Data 1

Our primary source of activity-based pollution is the IPPS database, with detailed (ISIC-3) pollution coefficients per unit of output for:

1. SO₂
2. NO₂
3. CO₂
4. PART – suspended particulate intensity index
5. VOC – volatile organic compounds
6. BOD – water pollution measured by biological oxygen demand
7. TSS – total suspended solids TOXAIR – airborne toxic index
8. TOXWAT – waterborne toxic index
9. TOXSOL – soil retentive toxic index
10. BIOAIR – bioaccumulative toxic metals - airborne
11. BIOWAT – bioaccumulative toxic metals - waterborne
12. BIOSOL – bioaccumulative toxic metals – soil retentive

From output to input based pollution modeling

An important drawback of IPPS and other emission data is stagnation bias, they are output based.

Using these to model abatement is biased against growth – abatement can only be achieved by reducing output.

In reality, firms substitute other inputs and technology to meet new standards without sacrificing growth.

Pollution Data 2

1. US EPA National Emission Trends

- Annual, 2000 most recent
- Point, Area, Mobile sources
- Point by SIC4, state
- Area and Mobile by “source classification code” (SCC)
- Partial allocation of area and mobile sources to SIC4 possible

2. California Monitoring Data

Energy Data

- Initial data consist of LBL energy flow tables and inter-industry data in the SAM
- These need to be reconciled so detailed production and consumption are consistent with aggregate flow patterns
- Fuel use and electricity generation/use are modeled in considerable detail
 - Up to six fuels and electricity for up to 104 activities and 15 final demand groups

Current Status of the Model (FY04, Q2)

- Prototype Model
 - A detailed working prototype of the model has been completed.
 - This will be used for preliminary analysis of baseline conditions to 2020.
- Initial Database
 - Initial and consistent estimates have been obtained for a dataset of full dimension. This will be tested for robustness in baseline simulations with the prototype model to determine data components needing more intensive estimation.

Scenario Options

External Shocks

- Prices
 - Energy and other resources
 - Other export/import prices
- Productivity and efficiency trends
- Demographic and migratory trends

Policy Options

- Incentive schemes, e.g. taxes/subsidies for abatement, clean up, and technology adoption
- Cap and trade schemes
- Energy market regulation
- Exogenous (e.g. federal) policy shocks
 - Taxes and subsidies
 - Regulation (env., trade, labor, R&D, etc.)

Extensions

- Learning models
- Endogenous technical change
- Trading mechanisms
- Carbon sequestration
- Urbanization and regionalization
- Location/mapping
- Integration of water and land resources
- Public health modeling – closing the economy/environment loop